

**What is claimed is:**

1. A process for forming oligomers, comprising the steps of:
  - (1) forming a reaction mixture, substantially free of solvent and carboxylic acid-monomers and their salts, comprising:
    - (i) 0.5 to 99.95% by weight, based on the weight of said reaction mixture, of at least one ethylenically-unsaturated monomer; and
    - (ii) 0.05 to 25% by weight, based on the weight of said ethylenically-unsaturated monomer, of at least one free-radical initiator; and
  - (2) continuously passing said reaction mixture through a heated zone wherein said reaction mixture is maintained at a temperature of at least 150°C and a pressure of at least 30 bars for from 0.1 seconds to 4 minutes to form terminally-unsaturated oligomers.
2. A process for forming oligomers having a degree of polymerization of at least 4, comprising the steps of:
  - (1) forming a reaction mixture, substantially free of carboxylic-containing monomers and their salts, comprising:
    - (i) 0.5 to 99.95% by weight, based on the weight of said reaction mixture, of at least one ethylenically-unsaturated monomer; and
    - (ii) 0.05 to 25% by weight, based on the weight of said ethylenically-unsaturated monomer, of at least one free-radical initiator; and
  - (2) continuously passing said reaction mixture through a heated zone wherein said reaction mixture is maintained at a temperature of at least 150°C and a pressure of at least 30 bars for from 0.1 seconds to 4 minutes to form terminally-unsaturated oligomers.

3. The process of claims 1 or 2, wherein step (2) is conducted in a tubular reactor having no moving parts.
4. The process of claims 1 or 2, wherein said ethylenically-unsaturated monomer is at least one monomer selected from the group consisting of n-alkyl(meth)acrylates, branched alkyl(meth)acrylates, cycloalkyl(meth)acrylates, straight chain or branched haloalkyl(meth)acrylates, aromatic alkyl(meth)acrylates, aromatic (meth)acrylates, hydroxyalkyl(meth)acrylates, heterocyclyl (meth)acrylates, aminoalkyl(meth)acrylates, ether-containing (meth)acrylates, silicon-containing (meth)acrylates, (meth)acrylamides, epoxide-containing (meth)acrylates, unsaturated alkyl(meth)acrylates, (meth)acrylate esters derived from (poly)unsaturated vegetable oils, terminal alkenes, aralkenes, heterocyclyl alkenes, dienes, vinyl halides, vinyl esters, vinyl ketones, aldehyde-containing vinyl functionality, epoxyalkenes, vinyl monomers, vinylsilanes, alkoxyvinylsilanes, unsaturated diesters, and functional (meth)acrylates.
5. The process of claims 1 or 2, wherein said reaction mixture comprises at least two different ethylenically-unsaturated monomers.
6. The process of claims 1 or 2, wherein said reaction mixture comprises at least three different ethylenically-unsaturated monomers.
7. The process of claim 2, wherein said reaction mixture further comprises 0% to 99.5% solvent.
8. The process of claim 7, wherein said solvent is at least one solvent selected from the group consisting of tetrahydrofuran, acetone, ethyl acetate, methyl alcohol, butyl alcohol, hexane, heptane, benzene, toluene, xylene, carbon dioxide, water, and mixtures thereof.

9. The process of claims 1 or 2, further comprising the step of:  
(3) hydrogenating said terminally-unsaturated oligomers.
10. The process of claims 1 or 2 wherein said heated zone is maintained at a temperature of from 200°C to 500°C.
11. The process of claims 1 or 2 wherein said heated zone is maintained at a temperature of from 275°C to 450°C.
12. The process of claims 1 or 2 wherein said heated zone is maintained at a pressure of from 70 bars to 350 bars.
13. The process of claims 1 or 2 wherein said heated zone is maintained at a pressure of from 200 bars to 300 bars.
14. The process of claims 1 or 2 wherein said reaction mixture is maintained in said heated zone for from 0.5 seconds to 2 minutes.
15. The process of claims 1 or 2 wherein said reaction mixture is maintained in said heated zone for from 1 second to 1 minute.
16. A process for forming oligomers of vinyl acetate, comprising the steps of:  
(1) forming a reaction mixture, substantially free of carboxylic-containing monomers and their salts, comprising:  
(i) 0.5 to 99.95% by weight, based on the weight of said reaction mixture, of vinyl acetate; and  
(ii) 0.05 to 25% by weight, based on the weight of said vinyl acetate, of at least one free-radical initiator; and  
(2) continuously passing said reaction mixture through a heated zone wherein said reaction mixture is maintained at a temperature of at least 150°C and a pressure of at least 30 bars for from 0.1 seconds to 4 minutes to form oligomers of vinyl acetate.

17. A process for forming oligomers of vinyl alcohol, comprising the steps of:

(1) forming a reaction mixture, substantially free of carboxylic-containing monomers and their salts, comprising:

(i) 0.5 to 99.95% by weight, based on the weight of said reaction mixture, of vinyl acetate; and

(ii) 0.05 to 25% by weight, based on the weight of said vinyl acetate, of at least one free-radical initiator;

(2) continuously passing said reaction mixture through a heated zone wherein said reaction mixture is maintained at a temperature of at least 150°C and a pressure of at least 30 bars for from 0.1 seconds to 4 minutes to form oligomers of vinyl acetate; and

(3) hydrolyzing said oligomers of vinyl acetate in the presence of a catalyst to form oligomers of vinyl alcohol.

18. A process for forming oligomers of vinyl alcohol, comprising the steps of:

(1) forming a reaction mixture, substantially free of carboxylic-containing monomers and their salts, comprising:

(i) 0.5 to 99.95% by weight, based on the weight of said reaction mixture, of vinyl acetate; and

(ii) 0.05 to 25% by weight, based on the weight of said vinyl acetate, of at least one free-radical initiator;

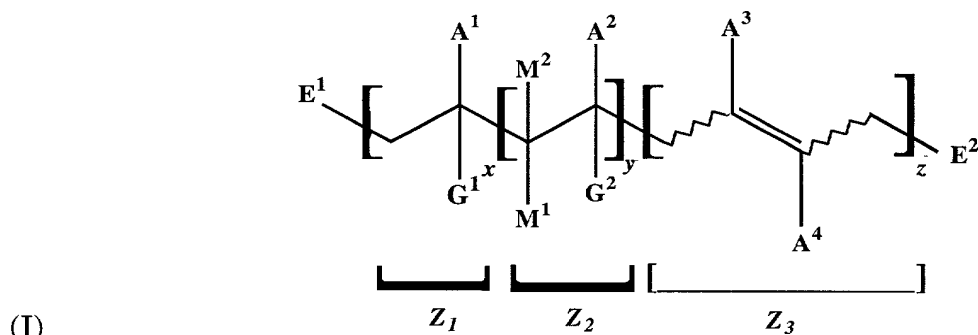
(2) continuously passing said reaction mixture through a heated zone wherein said reaction mixture is maintained at a temperature of at least 150°C and a pressure of at least 30 bars for from 0.1 seconds to 4 minutes to form oligomers of vinyl acetate; and

(3) transesterifying said oligomers of vinyl acetate with an alcohol in the presence of a catalyst to form oligomers of vinyl alcohol.

19. The process of claims 16-18 wherein step (2) is conducted in a tubular reactor having no moving parts.

20. A mixture, comprising:

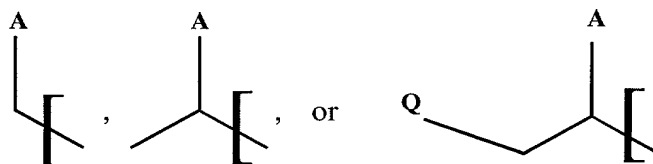
- (1) about 50 to 90% by weight, based on the weight of the mixture, of a first oligomer having terminal unsaturation of Formula (I):



where at least one of  $E^1$  and  $E^2$  is an endgroup of the formula:



and when only one of said  $E^1$  and  $E^2$  is an endgroup of Formula (II) then said other of said  $E^1$  and  $E^2$  is selected independently from H,

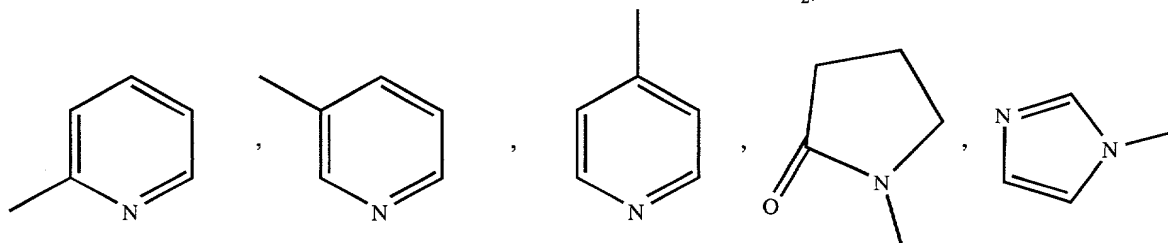


and where

$A, A^1$  and  $A^2$  = independently selected from -H;  
 $C_1$ - $C_{50}$  straight-chain or branched alkyl,  
 optionally substituted with a  $Y$  group;  
 $C_2$ - $C_{50}$  straight-chain or branched alkenyl  
 containing 1-5 double bonds, optionally  
 substituted with 1-2  $Y$  groups;  
 $C_5$ - $C_8$  cycloalkyl,  $C_5$ - $C_8$  cycloalkenyl;  
 phenyl,  $(CH_2)_m$ -phenyl, 1- or 2-naphthyl;  
 $-(C=O)H$ ;  $-C(OR^1)_2H$ ;  
 $-(C=O)R^1$ ,  $-(C=O)CF_3$ ;  $-C(OR^1)_2R^1$ ;  
 $-(C=O)OR$ ,  $-O(C=O)R^1$ ;  $-(C=O)Cl$ ;  
 $-O(C=O)OR^1$ ;  $-OR$ ;  
 $-(C=O)NH_2$ ,  $-(C=O)NHR^1$ ,  $-(C=O)N(R^1)_2$ ,  
 $-NH(C=O)R^1$ ,  $-NH(C=O)H$ ,  
 $-(C=O)NH(CH_2)_m(NH_3)^{(+)}(X)^{(-)}$ ,

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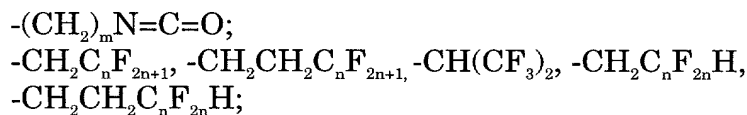
$-(C=O)NH(CH_2)_m(NR^1)_2$ ;  
 $-Si(OR^1)_3$ ,  $-Si(OR^1)_2R^1$ ,  $-Si(OR^1)(R^1)_2$ ,  
 $-Si(R^1)_3$ ;  
 $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ ;  
 $-C\equiv N$ ; oxiranyl;  
 $-NH(C=O)NH_2$ ,  $-NH(C=O)NHR^1$ ,  
 $-NH(C=O)N(R^1)_2$ ;



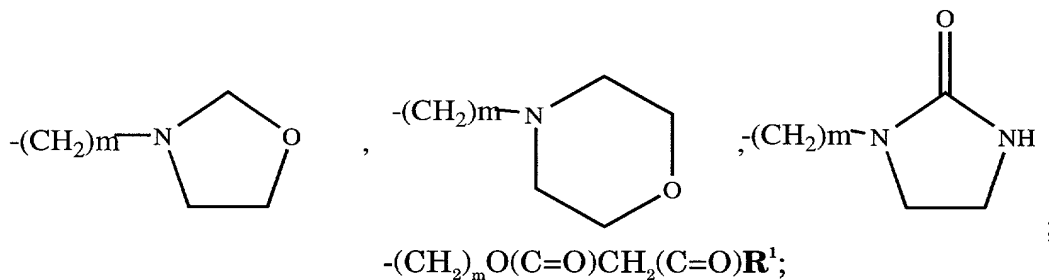
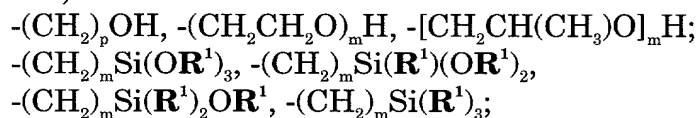
$-CH_2C_nF_{2n+1}$ ,  $-CH_2CH_2C_nF_{2n+1}$ ,  $-CH(CF_3)_2$ ,  
 $-CH_2C_nF_{2n}H$ ,  $-CH_2CH_2C_nF_{2n}H$ ;  
 $-P(=O)(OR^1)_3$ ,  $-S(=O)_2(OR^1)$ ,  $-S(=O)_2R^1$ ;

- $A^3, A^4 =$  independently selected from  $-H$ ,  $-F$ ,  $-Cl$ ,  $-Br$ ,  $R^1$ ;  
 $G^1, G^2 =$  independently selected from  $-H$ ,  $-CH_3$ ,  $-(CH_2)_mCO_2R^1$ ,  
 $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ ;  
 $M^1, M^2 =$  independently selected from  $-H$ ,  $-C\equiv N$ ,  $-(C=O)OR^1$ ,  $-F$ ,  
 $-Cl$ ,  $-Br$ ,  $-I$ ;  
 $Q =$   $C_1$ - $C_8$  straight-chain or branched alkyl,  $-OR^3$ , residue  
 from radical decomposition of azo initiators  
 (azonitrile, azoamidine, cyclic azoamidine, azoamide,  
 azoalkyl classes) such as  $-C(R^4)_2C\equiv N$ ;  
 $R =$   $C_1$ - $C_{50}$  straight-chain or branched alkyl,  
 $C_2$ - $C_{50}$  straight-chain or branched alkenyl containing 1-  
 5 double bonds;  
 $C_5$ - $C_8$  cycloalkyl,  $C_5$ - $C_8$  cycloalkenyl;  
 phenyl,  $(CH_2)_m$ -phenyl, 1- or 2-naphthyl,  
 -4-benzoylphenyl (where any phenyl group may be  
 substituted with up to 2  $R^2$ ), anthracenyl,  
 anthracenylmethyl;  
 $-(CH_2)_mO(C=O)R^1$ ,  $-(CH_2)_m(C=O)OR^1$ ;  
 $-(CH_2)_m(C=O)R^1$ ;  
 $-(CH_2)_m(C=O)NH_2$ ,  $-(CH_2)_m(C=O)NHR^1$ ,  
 $-(CH_2)_m(C=O)NH(R^1)_2$ ;  
 $-(CH_2)_mN(R^1)_2$ ,  $-(CH_2)_mNH_3^{(+)}X^{(-)}$ ;  
 $-(CH_2)_mOR^1$ ,  $-(CH_2CH_2O)_mR^1$ ,  $-(CH_2CH(CH_3)O)_mR^1$ ,  
 -2-tetrahydrofuranlyl;

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$$-(\text{CH}_2)_m \text{HC} \begin{array}{c} \diagup \text{O} \diagdown \\ \text{---} \end{array} \text{CH}_2$$
, linear alkanes containing 1-5 epoxy groups derived from (poly)unsaturated vegetable oils;



$\mathbf{R}^1$  = independently selected from  $\text{C}_1$ - $\text{C}_8$  straight chain or branched alkyl where  $(\mathbf{R}^1)_2$  may constitute a  $\text{C}_5$ - $\text{C}_8$  cycloalkyl group; phenyl,  $-\text{CH}_2\text{phenyl}$ ;

$\mathbf{R}^2$  =  $\text{C}_1$ - $\text{C}_6$  straight chain or branched alkyl,  $\text{C}_1$ - $\text{C}_6$  straight chain or branched alkoxy,  $-\text{CHO}$ ,  $-(\text{C}=\text{O})\text{OR}^1$ ,  $-\text{N}(\mathbf{R}^1)_2$ ,  $-\text{NO}_2$ ,  $-(\text{C}=\text{O})\text{N}(\mathbf{R}^1)_2$ ,  $-\text{CF}_3$ ,  $-(\text{C}=\text{O})\mathbf{R}^1$ ;  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ ;

$\mathbf{R}^3$  =  $-\text{H}$ ,  $\text{C}_1$ - $\text{C}_8$  straight chain or branched alkyl,  $-\mathbf{R}^1(\text{C}=\text{O})$ ,  $-\mathbf{R}^1(\text{C}=\text{O})\text{O}$ ;

$\mathbf{R}^4$  =  $\text{C}_1$ - $\text{C}_{18}$  straight-chain alkyl,  $\text{C}_5$ - $\text{C}_8$  cycloalkyl wherein the two adjacent  $\mathbf{R}^4$  groups may together form a 5-8 membered ring,  $\text{C}_1$ - $\text{C}_4$  alkoxy-substituted straight-chain or branched  $\text{C}_1$ - $\text{C}_8$  alkyl groups;

$\mathbf{X}^{(-)}$  =  $-\text{F}^{(-)}$ ,  $-\text{Cl}^{(-)}$ ,  $-\text{Br}^{(-)}$ ,  $-\text{I}^{(-)}$ ,  $-\text{HSO}_4^{(-)}$ ,  $-\text{H}_2\text{PO}_3^{(-)}$ ;

$\mathbf{Y}$  =  $-\text{OH}$ ,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ ,  $-\text{NH}_2$ ,  $-\text{N}(\mathbf{R}^1)_2$ ;

$m$  = 1-8

$n$  = 1-18

$p$  = 2-8

$x$  = 0-49

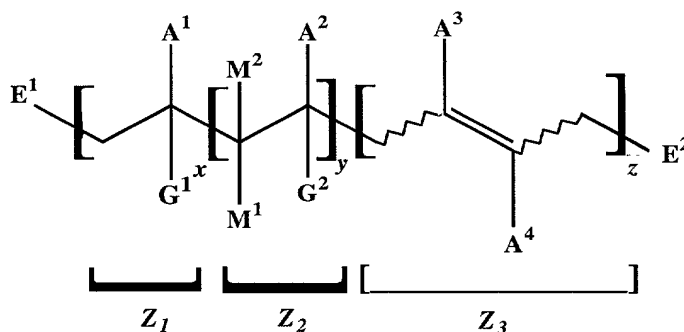
$y$  = 0-49

$$z = 0-49$$

$$x + y + z \leq 49; \text{ and}$$

- (2) about 10 to 50% by weight, based on the weight of the mixture, of a second oligomer of Formula (I),

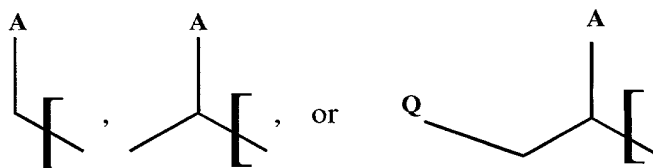
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(I)

where

$E^1$  and  $E^2$  = independently selected from H,



$A, A^1$  and  $A^2$  = independently selected from -H;

$C_1$ - $C_{50}$  straight-chain or branched alkyl,  
optionally substituted with a Y group;  
 $C_2$ - $C_{50}$  straight-chain or branched alkenyl  
containing 1-5 double bonds, optionally  
substituted with 1-2 Y groups;  
 $C_5$ - $C_8$  cycloalkyl,  $C_5$ - $C_8$  cycloalkenyl;  
phenyl,  $(CH_2)_m$ -phenyl, 1- or 2-naphthyl;  
- $(C=O)H$ ; - $C(OR^1)_2H$ ;  
- $(C=O)R^1$ , - $(C=O)CF_3$ ; - $C(OR^1)_2R^1$ ;  
- $(C=O)OR$ , - $O(C=O)R^1$ ; - $(C=O)Cl$ ;  
- $O(C=O)OR^1$ ; - $OR$ ;  
- $(C=O)NH_2$ , - $(C=O)NHR^1$ , - $(C=O)N(R^1)_2$ ,  
- $NH(C=O)R^1$ , - $NH(C=O)H$ ,  
- $(C=O)NH(CH_2)_m(NH_3)^{(+)}(X)^{(-)}$ ,  
- $(C=O)NH(CH_2)_m(NR^1)_2$ ;  
- $Si(OR^1)_3$ , - $Si(OR^1)_2R^1$ , - $Si(OR^1)(R^1)_2$ ,  
- $Si(R^1)_3$ ;  
-F, -Cl, -Br, -I;  
- $C\equiv N$ ; oxiranyl;  
- $NH(C=O)NH_2$ , - $NH(C=O)NHR^1$ ,  
- $NH(C=O)N(R^1)_2$ ;

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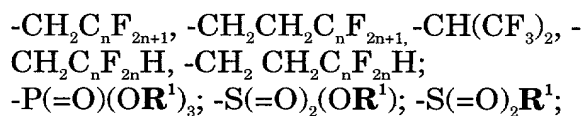
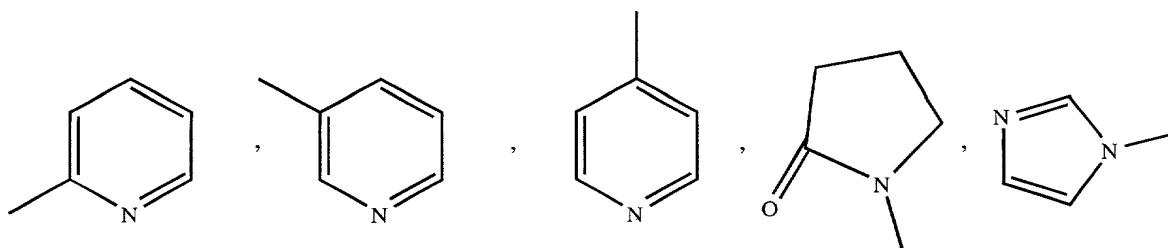
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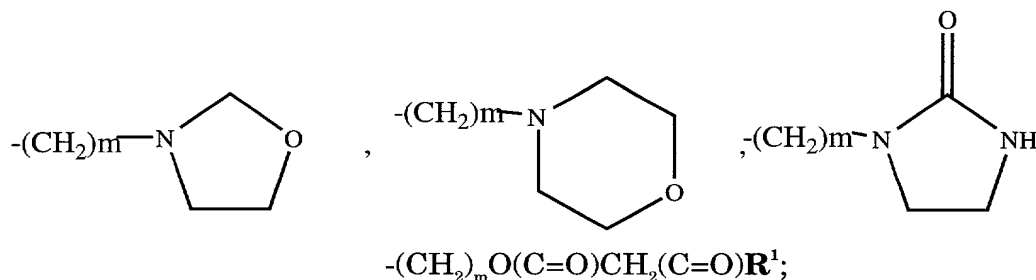
- $\text{A}^3, \text{A}^4 =$  independently selected from -H, -F, -Cl, -Br,  $\text{R}^1$ ;
- $\text{G}^1, \text{G}^2 =$  independently selected from -H, -CH<sub>3</sub>,  $-(\text{CH}_2)_m\text{CO}_2\text{R}^1$ , -F, -Cl, -Br, -I;
- $\text{M}^1, \text{M}^2 =$  independently selected from -H, -C≡N,  $-(\text{C}=\text{O})\text{OR}^1$ , -F, -Cl, -Br, -I;
- $\text{Q} =$  C<sub>1</sub>-C<sub>8</sub> straight-chain or branched alkyl, -OR<sup>3</sup>, residue from radical decomposition of azo initiators (azonitrile, azoamidine, cyclic azoamidine, azoamide, azoalkyl classes) such as  $-\text{C}(\text{R}^4)_2\text{C}\equiv\text{N}$ ;
- $\text{R} =$  C<sub>1</sub>-C<sub>50</sub> straight-chain or branched alkyl, C<sub>2</sub>-C<sub>50</sub> straight-chain or branched alkenyl containing 1-5 double bonds; C<sub>5</sub>-C<sub>8</sub> cycloalkyl, C<sub>5</sub>-C<sub>8</sub> cycloalkenyl; phenyl, (CH<sub>2</sub>)<sub>m</sub>-phenyl, 1- or 2-naphthyl, -4-benzoylphenyl (where any phenyl group may be substituted with up to 2  $\text{R}^2$ ), anthracenyl, anthracenylmethyl;  $-(\text{CH}_2)_m\text{O}(\text{C}=\text{O})\text{R}^1$ ,  $-(\text{CH}_2)_m(\text{C}=\text{O})\text{OR}^1$ ;  $-(\text{CH}_2)_m(\text{C}=\text{O})\text{R}^1$ ;  $-(\text{CH}_2)_m(\text{C}=\text{O})\text{NH}_2$ ,  $-(\text{CH}_2)_m(\text{C}=\text{O})\text{NHR}^1$ ,  $-(\text{CH}_2)_m(\text{C}=\text{O})\text{NH}(\text{R}^1)_2$ ;  $-(\text{CH}_2)_m\text{N}(\text{R}^1)_2$ ,  $-(\text{CH}_2)_m\text{NH}_3^{(+)}\text{X}^{(-)}$ ;  $-(\text{CH}_2)_m\text{OR}^1$ ,  $-(\text{CH}_2\text{CH}_2\text{O})_m\text{R}^1$ ,  $-(\text{CH}_2\text{CH}(\text{CH}_3)\text{O})_m\text{R}^1$ , -2-tetrahydrofuranyl;  $-(\text{CH}_2)_m\text{N}=\text{C}=\text{O}$ ;  $-\text{CH}_2\text{C}_n\text{F}_{2n+1}$ ,  $-\text{CH}_2\text{CH}_2\text{C}_n\text{F}_{2n+1}$ ,  $-\text{CH}(\text{CF}_3)_2$ ,  $-\text{CH}_2\text{C}_n\text{F}_{2n}\text{H}$ ,  $-\text{CH}_2\text{CH}_2\text{C}_n\text{F}_{2n}\text{H}$ ;

$-(CH_2)_m HC \begin{array}{c} \diagup O \diagdown \\ \text{epoxy} \end{array} CH_2$ , linear alkanes containing 1-5 epoxy groups derived from (poly)unsaturated vegetable oils;

$-(CH_2)_p OH$ ,  $-(CH_2CH_2O)_m H$ ,  $-[CH_2CH(CH_3)O]_m H$ ;

$-(CH_2)_m Si(OR^1)_3$ ,  $-(CH_2)_m Si(R^1)(OR^1)_2$ ,

$-(CH_2)_m Si(R^1)_2 OR^1$ ,  $-(CH_2)_m Si(R^1)_3$ ;



$R^1$  = independently selected from  $C_1$ - $C_8$  straight chain or branched alkyl where  $(R^1)_2$  may constitute a  $C_5$ - $C_8$  cycloalkyl group; phenyl,  $-CH_2$ phenyl;

$R^2$  =  $C_1$ - $C_6$  straight chain or branched alkyl,  $C_1$ - $C_6$  straight chain or branched alkoxy,  $-CHO$ ,  $-(C=O)OR^1$ ,  $-N(R^1)_2$ ,  $-NO_2$ ,  $-(C=O)N(R^1)_2$ ,  $-CF_3$ ,  $-(C=O)R^1$ ;  $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ ;

$R^3$  =  $-H$ ,  $C_1$ - $C_8$  straight chain or branched alkyl,  $-R^1(C=O)$ ,  $-R^1(C=O)O$ ;

$R^4$  =  $C_1$ - $C_{18}$  straight-chain alkyl,  $C_5$ - $C_8$  cycloalkyl wherein the two adjacent  $R^4$  groups may together form a 5-8 membered ring,  $C_1$ - $C_4$  alkoxy-substituted straight-chain or branched  $C_1$ - $C_8$  alkyl groups;

$X^{(-)}$  =  $-F^{(-)}$ ,  $-Cl^{(-)}$ ,  $-Br^{(-)}$ ,  $-I^{(-)}$ ,  $-HSO_4^{(-)}$ ,  $-H_2PO_3^{(-)}$ ;

$Y$  =  $-OH$ ,  $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ ,  $-NH_2$ ,  $-N(R^1)_2$ ;

$m$  = 1-8

$n$  = 1-18

$p$  = 2-8

$x$  = 0-49

$y$  = 0-49

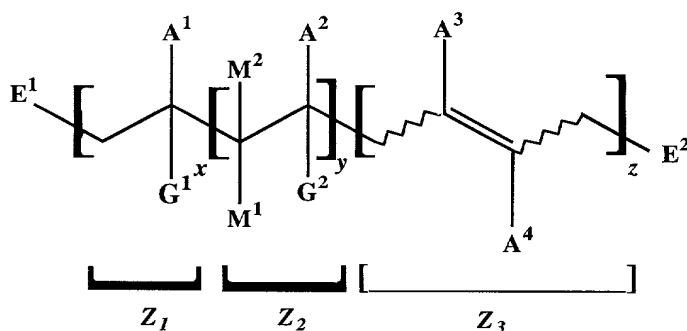
$z$  = 0-49

$x + y + z \leq 49$ .

21. The mixture of claim 20 wherein said oligomers are formed from at least one ethylenically-unsaturated monomer selected from the group consisting of n-alkyl(meth)acrylates, branched alkyl(meth)acrylates, cycloalkyl (meth)acrylates, straight chain or branched haloalkyl(meth)acrylates, aromatic alkyl(meth)acrylates, aromatic (meth)acrylates, hydroxyalkyl(meth)acrylates, heterocyclyl (meth)acrylates, aminoalkyl (meth)acrylates, ether-containing (meth)acrylates, silicon-containing (meth)acrylates, (meth)acrylamides, epoxide-containing (meth)acrylates, unsaturated alkyl(meth)acrylates, (meth)acrylate esters derived from (poly)unsaturated vegetable oils, terminal alkenes, aralkenes, heterocyclyl alkenes, dienes, vinyl halides, vinyl esters, vinyl ketones, aldehyde-containing vinyl functionality, epoxyalkenes, vinyl monomers vinylsilanes, alkoxyvinylsilanes, unsaturated diesters, and functional (meth)acrylates.

22. A composition, consisting essentially of:

(a) at least one oligomer of the formula:

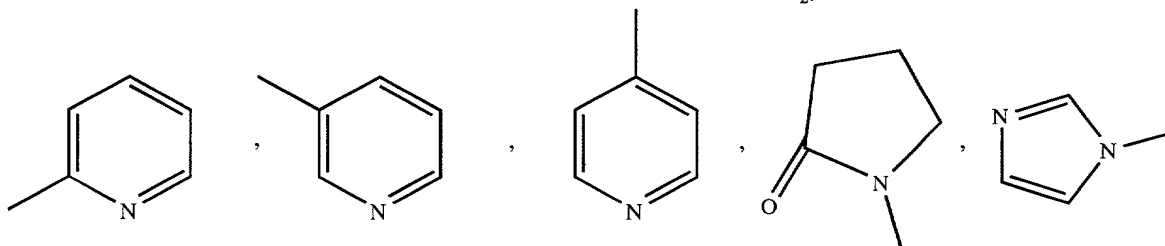


(I)

where

A, A<sup>1</sup> and A<sup>2</sup> = independently selected from -H;  
 C<sub>1</sub>-C<sub>50</sub> straight-chain or branched alkyl,  
 optionally substituted with a Y group;  
 C<sub>2</sub>-C<sub>50</sub> straight-chain or branched alkenyl  
 containing 1-5 double bonds, optionally  
 substituted with 1-2 Y groups;  
 C<sub>5</sub>-C<sub>8</sub> cycloalkyl, C<sub>5</sub>-C<sub>8</sub> cycloalkenyl;  
 phenyl, (CH<sub>2</sub>)<sub>m</sub>-phenyl, 1- or 2-naphthyl;  
 -(C=O)H; -C(OR<sup>1</sup>)<sub>2</sub>H;  
 -(C=O)R<sup>1</sup>, -(C=O)CF<sub>3</sub>; -C(OR<sup>1</sup>)<sub>2</sub>R<sup>1</sup>;  
 -(C=O)OR, -O(C=O)R<sup>1</sup>; -(C=O)Cl;

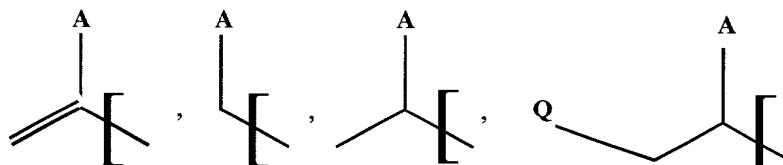
$-\text{O}(\text{C}=\text{O})\text{OR}^1$ ;  $-\text{OR}$ ;  
 $-(\text{C}=\text{O})\text{NH}_2$ ,  $-(\text{C}=\text{O})\text{NHR}^1$ ,  $-(\text{C}=\text{O})\text{N}(\text{R}^1)_2$ ,  
 $-\text{NH}(\text{C}=\text{O})\text{R}^1$ ,  $-\text{NH}(\text{C}=\text{O})\text{H}$ ,  
 $-(\text{C}=\text{O})\text{NH}(\text{CH}_2)_m(\text{NH}_3)^{(+)}(\text{X})^{(-)}$ ,  
 $-(\text{C}=\text{O})\text{NH}(\text{CH}_2)_m(\text{NR}^1)_2$ ;  
 $-\text{Si}(\text{OR}^1)_3$ ,  $-\text{Si}(\text{OR}^1)_2\text{R}^1$ ,  $-\text{Si}(\text{OR}^1)(\text{R}^1)_2$ ,  
 $-\text{Si}(\text{R}^1)_3$ ;  
 $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ ;  
 $-\text{C}\equiv\text{N}$ ; oxiranyl;  
 $-\text{NH}(\text{C}=\text{O})\text{NH}_2$ ,  $-\text{NH}(\text{C}=\text{O})\text{NHR}^1$ ,  
 $-\text{NH}(\text{C}=\text{O})\text{N}(\text{R}^1)_2$ ;



$-\text{CH}_2\text{C}_n\text{F}_{2n+1}$ ,  $-\text{CH}_2\text{CH}_2\text{C}_n\text{F}_{2n+1}$ ,  $-\text{CH}(\text{CF}_3)_2$ ,  
 $\text{CH}_2\text{C}_n\text{F}_{2n}\text{H}$ ,  $-\text{CH}_2\text{CH}_2\text{C}_n\text{F}_{2n}\text{H}$ ;  
 $-\text{P}(=\text{O})(\text{OR}^1)_3$ ;  $-\text{S}(=\text{O})_2(\text{OR}^1)$ ;  $-\text{S}(=\text{O})_2\text{R}^1$ ;

$\text{A}^3, \text{A}^4 =$  independently selected from  $-\text{H}$ ,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $\text{R}^1$ ;

$\text{E}^1, \text{E}^2 =$  independently selected from  $-\text{H}$ ,



$\text{G}^1, \text{G}^2 =$  independently selected from  $-\text{H}$ ,  $-\text{CH}_3$ ,  $-(\text{CH}_2)_m\text{CO}_2\text{R}^1$ ,  
 $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ ;

$\text{M}^1, \text{M}^2 =$  independently selected from  $-\text{H}$ ,  $-\text{C}\equiv\text{N}$ ,  $-(\text{C}=\text{O})\text{OR}^1$ ,  $-\text{F}$ ,  
 $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ ;

$\text{Q} =$   $\text{C}_1$ - $\text{C}_8$  straight-chain or branched alkyl,  $-\text{OR}^3$ , residue  
 from radical decomposition of azo initiators  
 (azonitrile, azoamidine, cyclic azoamidine, azoamide,  
 azoalkyl classes) such as  $-\text{C}(\text{R}^4)_2\text{C}\equiv\text{N}$ ;

$\text{R} =$   $\text{C}_1$ - $\text{C}_{50}$  straight-chain or branched alkyl,  
 $\text{C}_2$ - $\text{C}_{50}$  straight-chain or branched alkenyl containing 1-  
 5 double bonds;

C<sub>5</sub>-C<sub>8</sub> cycloalkyl, C<sub>5</sub>-C<sub>8</sub> cycloalkenyl;  
phenyl, (CH<sub>2</sub>)<sub>m</sub>-phenyl, 1- or 2-naphthyl,  
-4-benzoylphenyl (where any phenyl group may be  
substituted with up to 2 R<sup>2</sup>), anthracenyl,  
anthracenylmethyl;

-(CH<sub>2</sub>)<sub>m</sub>O(C=O)R<sup>1</sup>, -(CH<sub>2</sub>)<sub>m</sub>(C=O)OR<sup>1</sup>;

-(CH<sub>2</sub>)<sub>m</sub>(C=O)R<sup>1</sup>;

-(CH<sub>2</sub>)<sub>m</sub>(C=O)NH<sub>2</sub>, -(CH<sub>2</sub>)<sub>m</sub>(C=O)NHR<sup>1</sup>,

-(CH<sub>2</sub>)<sub>m</sub>(C=O)NH(R<sup>1</sup>)<sub>2</sub>;

-(CH<sub>2</sub>)<sub>m</sub>N(R<sup>1</sup>)<sub>2</sub>, -(CH<sub>2</sub>)<sub>m</sub>NH<sub>3</sub><sup>(+)</sup>X<sup>(-)</sup>;


-(CH<sub>2</sub>)<sub>m</sub>OR<sup>1</sup>, -(CH<sub>2</sub>CH<sub>2</sub>O)<sub>m</sub>R<sup>1</sup>, -(CH<sub>2</sub>CH(CH<sub>3</sub>)O)<sub>m</sub>R<sup>1</sup>,

-2-tetrahydrofuranlyl;

-(CH<sub>2</sub>)<sub>m</sub>N=C=O;

-CH<sub>2</sub>C<sub>n</sub>F<sub>2n+1</sub>, -CH<sub>2</sub>CH<sub>2</sub>C<sub>n</sub>F<sub>2n+1</sub>, -CH(CF<sub>3</sub>)<sub>2</sub>, -CH<sub>2</sub>C<sub>n</sub>F<sub>2n</sub>H,

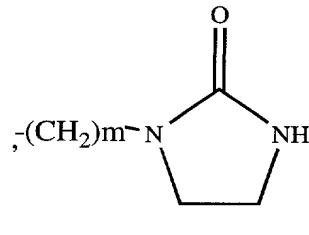
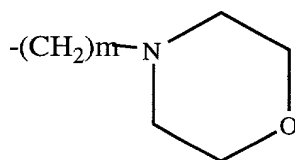
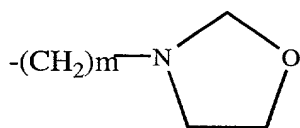
-CH<sub>2</sub>CH<sub>2</sub>C<sub>n</sub>F<sub>2n</sub>H;

  
 -(CH<sub>2</sub>)<sub>m</sub> HC—CH<sub>2</sub>, linear alkanes containing 1-5  
epoxy groups derived from (poly)unsaturated vegetable  
oils;

-(CH<sub>2</sub>)<sub>p</sub>OH, -(CH<sub>2</sub>CH<sub>2</sub>O)<sub>m</sub>H, -[CH<sub>2</sub>CH(CH<sub>3</sub>)O]<sub>m</sub>H;

-(CH<sub>2</sub>)<sub>m</sub>Si(OR<sup>1</sup>)<sub>3</sub>, -(CH<sub>2</sub>)<sub>m</sub>Si(R<sup>1</sup>)(OR<sup>1</sup>)<sub>2</sub>,

-(CH<sub>2</sub>)<sub>m</sub>Si(R<sup>1</sup>)<sub>2</sub>OR<sup>1</sup>, -(CH<sub>2</sub>)<sub>m</sub>Si(R<sup>1</sup>)<sub>3</sub>;



-(CH<sub>2</sub>)<sub>m</sub>O(C=O)CH<sub>2</sub>(C=O)R<sup>1</sup>;

**R<sup>1</sup>** = independently selected from C<sub>1</sub>-C<sub>8</sub> straight chain or  
branched alkyl where (R<sup>1</sup>)<sub>2</sub> may constitute a C<sub>5</sub>-C<sub>8</sub>  
cycloalkyl group; phenyl, -CH<sub>2</sub>phenyl;

**R<sup>2</sup>** = C<sub>1</sub>-C<sub>6</sub> straight chain or branched alkyl, C<sub>1</sub>-C<sub>6</sub> straight  
chain or branched alkoxy, -CHO, -(C=O)OR<sup>1</sup>, -N(R<sup>1</sup>)<sub>2</sub>,  
-NO<sub>2</sub>, -(C=O)N(R<sup>1</sup>)<sub>2</sub>, -CF<sub>3</sub>, -(C=O)R<sup>1</sup>; -F, -Cl, -Br, -I;

**R<sup>3</sup>** = -H, C<sub>1</sub>-C<sub>8</sub> straight chain or branched alkyl, -R<sup>1</sup>(C=O),  
-R<sup>1</sup>(C=O)O;

**R<sup>4</sup>** = C<sub>1</sub>-C<sub>18</sub> straight-chain alkyl, C<sub>5</sub>-C<sub>8</sub> cycloalkyl wherein  
the two adjacent R<sup>4</sup> groups may together form a 5-8

membered ring, C<sub>1</sub>-C<sub>4</sub> alkoxy-substituted straight-chain or branched C<sub>1</sub>-C<sub>8</sub> alkyl groups;

$$\mathbf{X}^{(-)} = -\mathbf{F}^{(-)}, -\mathbf{Cl}^{(-)}, -\mathbf{Br}^{(-)}, -\mathbf{I}^{(-)}, -\mathbf{HSO}_4^{(-)}, -\mathbf{H}_2\mathbf{PO}_3^{(-)};$$

$$\mathbf{Y} = -\mathbf{OH}, -\mathbf{F}, -\mathbf{Cl}, -\mathbf{Br}, -\mathbf{I}, -\mathbf{NH}_2, -\mathbf{N}(\mathbf{R}^1)_2;$$

$$\mathbf{m} = 1-8$$

$$\mathbf{n} = 1-18$$

$$\mathbf{p} = 2-8$$

$$\mathbf{x} = 0-49$$

$$\mathbf{y} = 0-49$$

$$\mathbf{z} = 0-49$$

$$\mathbf{x} + \mathbf{y} + \mathbf{z} \leq 49;$$

(b) at least one surfactant; and

(c) water.